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In-depth review of population projections

Prepared by the Office for National Statistics, United Kingdom and Statistics Canada

The present note is the in-depth review paper on population projections. The Bureau of the Conference of European Statisticians conducted the in-depth review at its meeting in October 2014. The purpose of the reviews is to improve coordination of statistical activities in the region of the United Nations Economic Commission for Europe, identify gaps or duplication of work, and address emerging issues.

The note summarises international statistical activities related to population projections, identifies issues and challenges, and makes recommendations for possible follow-up work.

The outcome of the review is provided in document ECE/CES/2015/8/Add.1.

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I. Executive summary

1. The paper provides a review of the current state of the making of population projections across a number of countries and international organizations. The review is not focused on the detailed methodology of making projections, but rather on current issues around projection making. The research in this paper is entirely internet based with minimal contact with projection makers in international organizations or national statistics institutes.

2. The report looks briefly at projections made by international organizations. It then provides short summaries of projection making in sixteen different countries, giving essential information about the projections, including how they are made. Some further description is also provided for a selection of the countries.

3. The analysis shows that while the basic cohort component method is universally used there is variation in how assumptions are determined, the frequency with which projections are made and the communication of uncertainty. There appears to be no single repository that holds information on these variations.

4. A brief summary is also provided of the recent UNECE/Eurostat Work Session held in Rome in October 2013, with links to the meeting's website.

5. The report then highlights some of the issues and challenges that are faced by projection makers, including:

(a) the lack of common definitions and methodologies;

(b) the lack of consensus about what should be the horizons and the frequency of projections;

(c) the development of methods for communicating uncertainty;

(d) the growing needs for projections of variables beyond age and sex and for alternative projection models able to handle this task (such as microsimulation models).

6. The report concludes with some suggested requirements for the presentation of projections and two key recommendations:

(a) the setting up of a joint committee. The joint committee would consider the elaboration of an international "best practice" guide for population projections, providing guidelines around some of the issues and challenges that projection makers face;

(b) the instigation of a database of information about projections. The database would contain basic information about sets of projections and how they are made to help inform users. Specific suggestions for information to be collected are made.

II. Introduction

7. The Bureau of the Conference of European Statisticians (CES) regularly reviews selected statistical areas in depth. The aim of the reviews is to improve coordination of statistical activities in the UNECE region, identify gaps or duplication of work, and address emerging issues. The review focuses on strategic issues and highlights concerns of statistical offices of both a conceptual and a coordinating nature. The current paper provides the basis for the review by summarising the international statistical activities in the selected area, identifying issues and problems, and making recommendations on possible follow-up actions.

8. The CES Bureau selected population projections for an in-depth review at its meeting in February 2014. The United Kingdom's Office for National Statistics (ONS) and

Statistics Canada were requested to prepare the paper providing the main basis for the review.

III. Scope/definition of the statistical area covered

9. In the Classification of Statistical Activities (CSA), population projections are categorised under Domain 1. Section 1.1 'Population and migration' which covers: work in population and demographic statistics, topics like demography, vital statistics, population structures and growth, demographic projections, families and households (marriages, divorces, household size), migration, refugees and asylum seekers. The area excludes causes of death.

10. Population projections in this paper cover both national and sub-national projections. Many of the issues involved are similar. This review covers only partially the projections of other variables beyond the basic demographic variables of age and sex.

11. With the limited time available, the research in this paper is almost entirely internet based with minimal discussion and contact with projection makers in individual countries, other than the UK and Canada, or with projection makers in international organizations. Any errors, therefore, are the responsibility of the authors.

IV. Overview of international statistical activities in the area

12. This section provides a brief overview of the past and ongoing activities of international organizations involved in making population projections, making clear the specialisation and value added of each organization. It also covers briefly some work carried out by academic groups.

13. At the international level there are two main international bodies that produce national population projections. The United Nations produces revised population projections every two years, the latest set being 2012-based.[1] In addition around once every ten years they produce long term projections, beyond a 100 year time horizon. Periodically Eurostat independently produces sets of population projections, the latest set, 2013-based, cover the time period 2013-2080 and were published in May 2014. The methodology document for this set will be published within the next two months. They project populations by age and sex for all EU28 Member States as well as Iceland, Norway and Switzerland.

14. A number of other organizations publish population projections at a national (or higher) level including Wittgenstein Centre for Demography and Global Human Capital in Austria, to which the International Institute for Applied Systems Analysis (IIASA) contributes. IIASA have previously produced their own projections[2]. Other international organizations that have produced their own projections include – the World Bank[3,4], the US Census Bureau[5] and the Population Reference Bureau.[6,7]

[1] http://esa.un.org/wpp/

[2] See for example http://www.iiasa.ac.at/publication/more_XB-04-001.php

[3] http://data.worldbank.org/data-catalog/population-projection-tables

[4] http://siteresources.worldbank.org/SCBEXTERNAL/Resources/Population_Projections.pdf (this is a good example of an inadequately labelled document as to which set of projections it refers to).

[5] Methodology here http://www.census.gov/population/international/data/idb/estandproj.php. It is notable that each country in this set of projections may have differing base dates, depending on the data available.

15. The Database of International Statistical Activities (DISA)[8] lists very few activities in terms of planned work in international statistics related to population projections under statistical activity 1.1. The only activity is to maintain and expand a population projections database "to achieve transparency in the use of population projections within OECD." Non EU countries involved include: Brazil, Bulgaria, China, Cyprus, India, Indonesia, Latvia, Lithuania, Russian Federation, South Africa.

16. A successful Joint Eurostat/UNECE Work Session on Demographic Projections, was held in Rome in October 2013[9] following previous meetings in 2010, 2007, 2005 and 1999. As well as sessions covering the usual population projection topics of setting assumptions for each of the three components of population change (fertility, mortality and migration), sessions were held on developing areas of interest in the topic area. There was a strand on stochastic methods in population projections and the use of Bayesian methodologies. A number of countries and organizations either produce, or are considering producing, stochastic projections (see Annex A).

17. The United Nations used probabilistic methods to set the assumptions in World Population Prospects 2012 revision. They have published interactive graphs for fertility and mortality, showing for each country, a selection of the trajectories run and the resulting probabilistic ranges.[10] An example for UK fertility is shown at Figure 1. These are excellent ways of communicating issues around uncertainty to the user. However, the essentially mechanistic nature of the process is still highly dependent on the assumptions made in the models used. They will also tend to assume trends will continue indefinitely.

18. The UN has also not yet developed a probabilistic method of producing migration assumptions for use in their projections. Therefore the overall projections cannot be described as stochastic. Currently stochastic projections tend to introduce uncertainty independently into each component. Ideally stochastic projections would also need to model relationships between components. This would be particularly true for a country still going through the demographic transition from a high fertility, high mortality population to a low fertility low mortality population.

[6] A 2001 paper reviewed a number of internationally produced population projections – see http://www.demographic-research.org/volumes/vol4/8/4-8.pdf.

[7] An excellent general piece on world population projections entitled "Dimensions of global population projections: what do we know about future population trends and structures?" (2010) Lutz W and Samir KC can be found here http://rstb.royalsocietypublishing.org/content/365/1554/2779.full.

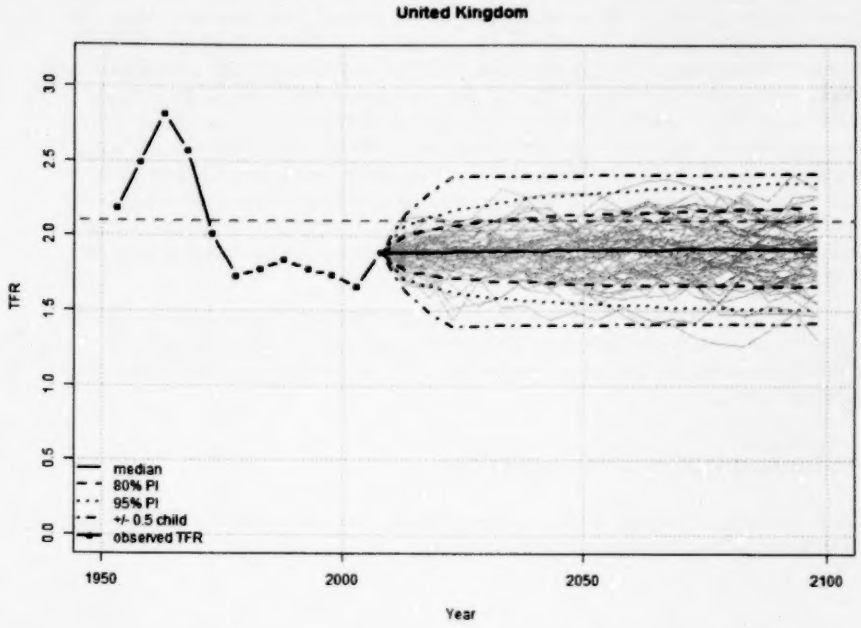
[8] http://www1.unece.org/stat/platform/display/DISA2013/1-+Demographic+and+social+statistics.

[9] http://www.unece.org/stats/documents/2013.10.projections.html.

[10] http://esa.un.org/wpp/fertility_figures/interactive-figures_TF-trajectories.htm.

Figure 1

An example page from the United Nations World Population prospects 2012 revision showing the results of the probabilistic assumptions for fertility, United Kingdom



Source: United Nations, Department of Economic and Social Affairs, Population Division (2013): World Population Prospects: The 2012 Revision, New York
http://esa.un.org/wpp/fertility_figures/interactive-figures_TF-trajectories.htm.

Explanation: These charts are from the Bayesian Hierarchical Modelling of total fertility that has been carried out with fertility estimates from the 2012 Revision of the World Population Prospects. Please note that only a small selection of the probabilistic trajectories of total fertility is displayed (gray lines) for illustration. The model is using 60,000 trajectories of projected total fertility. The median projection is the solid bold red line, and the 80% and 95% projection intervals are displayed as dashed and dotted red lines respectively. The high-low fertility variants in the 2012 Revision correspond to +/- 0.5 child around the median trajectory displayed as blue dashed lines. The replacement-level of 2.1 children per woman is plotted as green horizontal dashed line only for reference.

19. The 2013 Rome conference included sessions on projecting households and also on inclusion of additional population characteristics in projections. The centre piece of the conference was the reporting on a new set of world population projections incorporating components determined using level of education. This allowed both projections by education but also the influence of education to be played out in the assumptions. The approach is based on an evaluation of 500 international expert views. The projections do not confirm the common perception of a rapid increase in the number of migrants and suggest a shift in the education composition of migrants toward higher level of education attainment. The projections also suggested the world population would peak at 9.5 billion, not reaching the 10 billion projected by the UN.

20. Discussions highlighted that while differentials in education are clear for mortality, the issue is more complicated for fertility. Sensitivity of the results to assumptions and assessment of the performance of the projections were also discussed.[11]

21. All the projections above have so far been produced at the national level. Eurostat produced sub-national population projections as part of their 2008-based projections. This ambitious project produced population projections at the NUTS2 level for the EU-27 Member States, Norway and Switzerland. The projections show that population may increase in around two thirds of NUTS2 regions between 2008 and 2030. However, in 2030, slightly more than half of the regions are projected to continue to show an increase their population. The following caveat was given "Population projections are what-if scenarios that aim to provide information about the likely future size and structure of the population. Eurostat's regional population projections scenario is one of several possible population change scenarios at regional level based on assumptions for fertility, mortality and migration."[12] Eurostat are planning to produce a new set of sub-national projections in 2015.

22. Trying to produce a consistent set of projections across a large number of countries below the national level of geography is difficult as, not only do you have to project within country migration, all the other components need to be split by those lower level geographies too.

V. A summary of country practices

23. A country by country breakdown and a table at Annex A summaries key information about the projections from the following countries:

- Australia*
- Belgium
- Canada*
- Denmark
- Finland
- France*
- Germany*
- Italy*
- Netherlands*
- New Zealand*
- Norway*
- Portugal
- Spain*
- Switzerland
- United Kingdom*
- USA*

[11] http://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.11/2013/2013_Demographic_Projections_long_report_formatted_PV.pdf.

[12] http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-SF-10-001.

For those with asterisks web links and further information have been provided. The methods and practices of producing projections of the population across these countries present a number of issues and challenges.

VI. Issues and challenges

24. There are many issues and challenges in producing population projections. These can broadly be grouped into methodological challenges and practical issues, the latter particularly around the use of projections and communication of uncertainty/utility.

A. Methodological challenges

1. Stochastic methods, expert opinion and communicating uncertainty

25. In a panel study of world population projections, the National Academy of Sciences concludes the following as the greatest needs: more reliable baseline data; quicker updates to projections following new information; and, acknowledging uncertainty and developing methodologies to quantify it.[13]

26. In the current state of affairs, there is no scientific consensus on the best ways to proceed for estimating and communicating the uncertainty associated with projection exercises. It is a current topic of research and should remain so.

27. Alongside mathematical/statistical extrapolation methods, two key approaches in helping to set assumptions have come to the fore in recent years. To produce stochastic projections some demographers have gone down the Bayesian statistics route, often using past variations in population, or past projection errors, to inform their models. Others have preferred Delphi style methods using large groups of experts to produce stochastic projection assumptions.

28. The communication of uncertainty is useful for planners to assess risks associated with projects. However, just because either method is able to do this does not necessarily mean they are any better at correctly foreseeing the future. Measures of uncertainty based on past projection errors can be misleading when the demographic contexts differ or when the methods or the teams responsible for making the projections have changed. Measures of uncertainty based on past variations (such as time series) depend greatly on reference period used and the past demographic context. Finally, the use of expert opinion carries risks that knowledgeable and experienced projection makers may end up with a narrower range of uncertainty than is realistic, as they will be familiar with past assumptions. Experts may a form an opinion that converges towards a "correct" answer when actually that correct answer is just a reflection of past projection assumptions rather than giving true insight into future trends. As an example, experts have been found to consistently underestimate improvements in mortality. Further, it can be difficult to decide how to weight each opinion. Generally Delphi type questionnaires will ask people to identify their own expertise. Modesty or ego may affect such data.

29. The communication of uncertainty is not an easy task. It should be done in a way that it does not encourage the interpretation of projection results as predictions. Moreover, some of the more complex stochastic models may also be hard to communicate to the average user and may seem little more than a 'black box' approach.

[13] National Academy of Sciences. 2000. *Beyond Six Billion: Forecasting the World's Population.* Eds. J. Bongaarts and R.A. Bulatao. National Academies Press. 258p.

30. Communication of uncertainty through the use of variant projections or stochastic methods is less likely to be found in the production of sub-national population projections. This is likely to be because these projections tend to be for shorter time horizons, but also because of their greater level of complexity. However, the presence of smaller populations at the sub-national level and the additional component of interregional migration, which are often volatile, are strong arguments (where applicable) pointing towards the importance of communicating uncertainty using variant scenarios.

31. Stochastic style projections at least inherently show that there is a range of possible futures. Other ways of showing this are to make plausible alternative assumptions for each of the components (which is what the UK and Statistics Canada currently do). The individual effects of the alternative high or low assumptions can be demonstrated but they can also be combined to produce such variants as high/low populations, or young/old populations. Any communication of uncertainty needs to consider how the uncertainty increases over the length of the projection. Uncertainty around components is often almost symmetric, the possibility that uncertainty is asymmetric should be considered – although that can be more difficult for users to understand. It should not be forgotten as well that a further source of error in any projection can be the base population and any assessment should take account of any changes made to the base, or any inherent uncertainty in the base estimate.

2. Assessing population projection methodologies

32. There is a genuine methodological challenge to try and assess the success of different methodologies. The nature of projecting several decades into the future is that it is only several decades into the future that you can see how successful the projections were. One might consider applying the methods to data from several decades past (assuming it was available) and seeing if it can predict the present. While past success may be no guarantee of future success, historical time series of demographic data are becoming sufficient to carry out this type of analysis.

33. Some have questioned the value added, in terms of projection accuracy, of the cohort-component method over extrapolation and 'naïve' methods which are comparatively simpler and less costly to produce.[14] However, the cohort-component method holds at least two main advantages over simpler methods. Firstly, the structure of the cohort-component method mirrors and thus extends the structure of the data produced by national statistical agencies. Secondly, it allows for the elaboration of specific assumptions for each of the components of growth, facilitating an evaluation of the plausibility of said assumptions.

34. A crucial component of the quality of a projection exercise is the utility of the exercise as perceived by its users at the time they are made available. Thus, the quality of a projection exercise might relate more to its utility in the present, rather than in the future. Thus, the adoption of a given methodology based on the power of its accuracy should be weighed against other aspects such as its ease of interpretation and use, timeliness and cost.[15]

[14] See for instance: Rayer, S. 2008. Population Forecast Errors: A Primer for Planners, Journal of Planning Education and Research, 27: 417-430; and Tayman, J. and D.A. Swanson. 1996. On the utility of population projections. Demography 33(4): 523-28.

[15] See for instance: Yokum, J. Thomas, and J. S. Armstrong. 1995. Beyond accuracy: Comparison of criteria used to select forecasting methods. International Journal of Forecasting 11: 591-97; and Rayer 2008, ibidem.

35. In the context of population projections, it is the plausibility of the assumptions more than the outcomes themselves that should be evaluated.[16] The utility of a population projection is not in the future, it is in the present, as a tool to raise questions about the future.

36. A recent survey of European statistical agencies regarding their population projections program indicates that all statistical agencies see a need for improvement in the methods used to make assumptions; specifically, advancing the conventional methodology of scenario-based forecasts (stochastic/probabilistic forecasting methods, in contrast, did not appear to be a high priority for the majority of agencies). Other commonly-cited needs were a) greater expert involvement in the development of the projections and b) greater communication and more structured interactions with other national statistical agencies regarding their assumptions and methodologies[17,18].

3. Making assumptions

37. Generally the use of the cohort component method of ageing on population, adding projected births (generated via projected fertility rates) subtracting projected deaths (generated via projected mortality rates) and adding net migration (which may be either assumed numbers, either gross or net, or rates/probabilities) is universal. However, the methods of projecting the components may vary greatly.

38. It is possible to look at trends, particularly for fertility and mortality rates, on a period or cohort basis. And when projecting trends decisions need to be made as to:

- whether to continue trends indefinitely;
- the historical period the trends are taken from;
- whether to incorporate other characteristics or correlates into the setting of the trends, for example, should cause specific mortality be analysed to generate future mortality trends; and
- whether trends are derived purely from mathematical modelling or by the application of expert judgement – or a combination of the two.

39. Methods may be varied if the intention is to produce projections by age, sex and other characteristics. For example, to produce projections of the ethnic population it may be that additional assumptions are needed on transitions of people between ethnic categories based on changes in self-definition, or on differentials for some demographic behaviours - for example, higher or lower fertility among specific sub-groups of the population. Decisions also need to be made as to whether individual rates are produced by the variable concerned or whether proportions are applied to populations initially projected from the whole population. The US, for example, produces its population projections by assuming different rates for five different race or Hispanic groups.[19] Here they have

[16] Romaniuc, A. 2003. Reflection on Population Forecasting: From Predictions to Prospective Analysis. Canadian Studies in Population 30(1): 35-50.

[17] Prommer, I. and C. Wilson. 2006. An analytical summary of the current practices of definition of assumption making in population projections. International Institute for Applied Systems Analysis. Work Package 3, Deliverable D14. Contract no. SP23-Ct-2005-006637.

[18] Further on the topic of expert involvement, IIASA has recently developed an "argument-based approach" to surveying demography experts around the world about their views on future demographic trends. The exercise provides a model of a novel, systematic approach to developing projection assumptions (for more details, see: Lutz, W. 2009. Toward a systematic, argument-based approach to defining assumptions for population projections, Interim report IR-09-037. International Institute for Applied Systems Analysis.).

[19] http://www.census.gov/population/projections/files/methodology/methodstatement12.pdf.

individual rates for each of the groups but there is obviously no transition between groups.[20] A general principle, however, is that if you have to project a variable that is even harder to project than the population – for example, economic growth – then incorporating that variable into the projection of population is probably not worthwhile.

4. Top down or bottom up?

40. A key methodological issue often not considered is whether to produce population projections where a number of geographical areas are involved in a top down or bottom up way. For example, the Eurostat projections are produced in a bottom up way by applying their methodology to each of the countries and then adding the resulting projections together to get a figure for the EU in total. It would be possible to put together all the data and apply the methods to the total EU population and run the projection. The individual country projections could then be constrained to this total. There is scope for further research into this area.

41. This is also a question for individual countries to consider when thinking about sub-national projections. Statistics Canada, for example, employs a "hybrid bottom-up" approach to their projections, whereby target assumptions are first made at the Canada level and from that, assumptions are derived at the provincial and territorial level so as to sum to the desired national targets. A drawback of this approach is that the observed trends for individual sub-national regions may be eschewed when they differ considerably from the national average; however, in some cases this relates more to the volatility of trends in regions having very small population.

42. There is also an interesting methodological conundrum as to when the cohort component method may either cease to become robust – either because of the data requirements or because stochastic processes may start to intervene – for example when projecting very small areas or populations.[21] It may be that in these cases stochastic or probabilistic methods projecting the whole population outside the cohort component method are appropriate.

B. Practical issues

1. Terminology - projections or forecasts

43. Official projection makers tend to refer to their figures as projections rather than forecasts. To the lay person this debate may feel like semantics and to the user planning services or distributing budgets it is probably immaterial. The Australian Bureau of Statistics attempts to define the difference as follows[22]:

[20] Other projection techniques such as microsimulation methods can handle these transitions in an efficient way.

[21] For example work has been carried out to look at the smallest population for which calculating a lifetable is robust – see *Life expectancy at birth: methodological options for small population* National Statistics Methodological Series No.30 Barbara Toson and Allan Baker, Office for National Statistics,. http://www.ons.gov.uk/ons/guide-method/method-quality/specific/gss-methodology-series/index.html.

[22] http://www.abs.gov.au/websitedbs/a3121120.nsf/home/statistical+language+-+estimate+and+projection.

Type of information	The difference	Nature of assumptions
Projections indicate what future values for the population would be if the assumed patterns of change were to occur. They are not a prediction that the population will change in this manner.	While both involve analysis of data, the key difference between a forecast and a projection is the nature of the assertion in relation to the assumptions occurring.	A **projection** simply indicates a future value for the population if the set of underlying assumptions occur.
Forecasts speculate future values for the population with a certain level of confidence, based on current and past values as an expectation (prediction) of what will happen.		In a **forecast**, the assumptions represent expectations of actual future events.

44. One might argue that, for most projections where expert judgement is used alongside statistical extrapolation the projected components of fertility, mortality and migration are, in fact, forecasts. However, even in this situation as projection makers are interacting three 'forecasts', the result is effectively a projection. Much depends on the view of each of the assumptions made – including the sophistication of the analysis, the use of expert opinion and whether for the components the projection maker is speculating on the future trends in the components with a certain level of confidence. For sub-national projections the derivation of the component assumptions tends to be mechanistic and if this is the case the results are certainly projections and not forecasts.

45. A related issue is the fact that, despite the effort which agencies may make to distinguish between a forecast and a projection (i.e., through the use of multiple scenario variants, none labelled "most likely"), users inevitably turn to the middle variant and interpret it as a forecast and/or the scenario the most likely to occur. Keyfitz[23] questions which criteria should define a projection versus a forecast: is it the demographer's intention or the reader's use? Demographers in the process of building projection assumptions inevitably find themselves attempting to assess what outcomes are the most likely to occur. Therefore, the notion of predicting the future is subtly embedded within the projection assumption-building process.

2. Issues around the availability and comparability of many projections

46. A particular issue with projections (although it can happen for estimates, or even for data counts if there are definitional issues) is that comparisons of projections can be difficult. If a user wanted to compare population projections for two European countries for 2030 they would have the choice of a number of different sources – they could look at the countries' own statistical office's (NSO) projection, they could look at the Eurostat projections, they could look at the UN projections – or they could find projections by one of the other international bodies. Some knowledge may be needed to determine which numbers are appropriate. It is likely that for a developed European country the NSO projections will be produced using some expert knowledge and a sense for which methods those experts think work best for that country. However, the methods could be very different and the base year may be different. Projections by international bodies will tend to use the same base year and the same methodology but they may be more out of date and the methodology may be less sophisticated, as it needs to be applied to a large number of

[23] Keyfitz, N. 1972. On future population. Journal of the American Statistical Association 67(338): 347-63.

countries. It also may contain assumptions about trends continuing or attenuating that would not be applicable to the individual country but are sensible in terms of producing the projections as a whole.[24] It is only by understanding the projections assumptions and methodology that a user could decide which figures provided the best comparison for their use. It is vital, therefore, that information on the assumptions made is available and ideally NSOs should produce documents comparing their projections with those produced by international bodies. Where possible, international bodies should discuss the resulting assumptions from their methodologies with national NSOs to ensure that the assumptions do not produce completely unacceptable results.

47. The issue described above may be mirrored when projections are made across regions within a country. In the UK, Wales has produced a 2011-based set of sub-national projections that are not constrained to any national projections.[25] The publication is careful to only publish the figures for the local authorities in Wales, without adding up the figures to a total which would be different from the national population projection (in fact no 2011-based national projections were made for Wales).

48. The plethora of projections produced means that it is important that basic labelling of the projections includes the base year (including the point in the year) – something about the status of the projection (is it a main or principal projection or is it a variant), the name of the producer of the projection and whether it has been made consistent with any other projection.

49. The production of a best-practice guide for population projections would improve the comparability of different sets of population projections, ensuring common principles with regards to horizon, number of scenarios, dissemination and documentation.

3. How far forward should projections look?

50. Uncertainty increases the further into the future projections are made. So another practical issue is how long to actually run the projection for. Once projection models are projecting the demographic behaviour of a population that is already a projection (that is, you are projecting the fertility behaviour of women who themselves are not yet born) the results are even more uncertain. Thus projection makers tend to only project 60 years or so forward. By then all those under 60 in the population will have been projected.

51. In their review of current world projections, the National Academic Press suggests that beyond a period of 50 years, forecasts involve so much uncertainty that they should not be produced.[26]

52. A related issue may be the level of detail published further into the future. Both these issues may impact on users in that projections may not go to the horizon they need – for example, long-term planning of pension benefits. The different projection horizons, or decisions about levels of detail published, can make comparisons of long-term projections difficult.

53. Population projection users are interested in different time horizons – some may need to know many decades ahead, for example for housing planning, others may only need to know a few years, for example, for resource allocation. Projection makers need to

[24] A good example of this is that the UN used to assume developed countries returned to replacement level in the long term. While this might have been a sensible assumption at the time it was becoming increasingly unlikely for a number of European countries.

[25] http://wales.gov.uk/docs/statistics/2013/130723-local-authority-population-projections-2011-based-en.pdf.

[26] The National Academies Press. 2000. Beyond Six Billion: Forecasting the World's Population. Eds. J. Bongaarts, and R.D. Bulatao. National Academy of Sciences. 258 p.

consider this in the design of the methodology and the frequency with which projections are produced. They also need to consider this in the communication of any uncertainty – ensuring sufficient uncertainty is shown in the short term as demographic trends can vary substantially in short-time periods, both nationally but particularly at lower geographical levels.

4. How often should projections be made?

54. The frequency with which projections are made is also a practical decision (although it might be argued that if a measure of stability in the projections could be derived there is also potentially a methodological solution to be found here – although the methodology itself, including how sensitive it is to recent change will influence that stability). Infrequent projections tend to lead to large changes between projections deriving from big changes in all the components. This means that users may use out of date projections for quite some time. Equally, producing new projections every year – perhaps with quite minor changes – may frustrate users, who have to constantly update their work and, given that all projections are to a greater or lesser extent wrong, excessive production may just give a spurious sense of accuracy. Generally the frequency of projections made by national statistics institutes varies between two to five years although some have longer gaps.

55. Although some periodicity is needed (to ensure that knowledge is retained in national statistical institutes, to plan for resourcing in national statistical agencies and to give users expectation of when new projections will be available), the commitment of national statistical agencies to revise projections when the demographic situation has changed significantly could give users greater confidence in the projections produced.

5. Data quality and definitions

56. A further practical issue (although potentially one that may need methodological solutions) is the availability of data and the quality of that data. International organizations such as Eurostat and the UN have processes to try and produce consistent data series on consistent definitions, and have had in place an international data collection system to minimise burden on data provision by individual European countries.[27] However, definitional differences, for example, in who are counted as migrants, can have an effect on subsequent projections. Leaving aside the philosophical issue of whether projections are projecting the population estimates, including their definitional issues and flaws, or project the 'truth' it is vital that documentation of definitions is included alongside methodology.

57. A final challenge, which comes under both the practical and methodological headings, is the increasing importance of migration. Migration is complex as it has to be defined, and there can be a number of different dimensions that can be of interest to those using demographic estimates and projections. Migration, either international or subnational, can also be highly volatile, making it more difficult to develop assumptions about. Finally, the choice of the methodology used for the projection of migration tends to greatly impact the results (for example, using the multiregional model versus predetermined nets).

6. Needs for projection of variables beyond age and sex

58. There is an increasing demand for projections of sociodemographic variables beyond age and sex. This demand is likely to continue to grow in the future. For example, education is considered to be a key factor in determining how industrialized countries will overcome the challenges related to population aging or to climate change.[28] The importance

[27] http://unstats.un.org/unsd/demographic/meetings/egm/DYB_1103/docs/no_08.pdf

[28] For instance, in a recent report from the National Research Council, Wolfgang Lutz explain that education enhances the lives of people in many ways, citing benefits such as enhancing cognitive

of international migration in defining the composition of the national population is another factor that could boost the demand for the projection of some characteristics other than age and sex, such as foreign-born status, ethnic groups, or language.

59. Not only is there an added-value in projecting these additional variables, it can improve projections by age and sex as it allows to take into account the differentials in behavior among sub-groups of the population.[29]

60. Microsimulation has proven very powerful in the simultaneous projections of a large number of variables in Canada with the Demosim model.

61. Microsimulation models have long been used in science for forecasting, but their use in demographic projections is still rare. However, the on-going development of microsimulation models and of tools facilitating their use (such as programming language) should lead to a wider adoption and a better understanding of these techniques in the future.

VII. Conclusions and recommendations

62. The myriad uses to which population data, but particularly projections, can be put means that it is almost impossible for projection makers to take account of each stakeholder's needs – rather they must endeavour to produce the best population projections they can. However there are some specific actions which projections makers could take which would assist those who use projections.

63. All projections should be clearly labelled with the base year, the organization that produced the projection and any information about whether the projection has been made consistent with other projections.

64. The methodology used to derive the assumptions made in making the projections should be clearly published.

65. All projections should have some analysis which helps users understand the uncertainty inherent in making projections. In an ideal world there would be standard methods for describing uncertainty, however, unless projections were made with identical methods uncertainty will always be described slightly differently in each case. For projections made by the cohort component method there should be expression of uncertainty for each of the components.

66. As far as possible all population statistics, including projections should adhere to internationally agreed definitions – in particular those concerning migration.

67. National statistics institutes and international organizations that make projections should form a joint working group to periodically discuss approaches and review assumptions. Greater use should also be made of DISA to record activity. They might also want to consider providing guidance on issues such as:

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skills, enabling better learning from past experience and promoting higher incomes. Lutz mentions that higher levels of education can improve the population's adaptive capacity to respond to climate change. *Source*: National Research Council. (2014). Can Earth's and Society's Systems Meet the Needs of 10 Billion People? Summary of a Workshop. M. Mellody, Rapporteur. Board on Environmental Change and Society and Committee on Population,Division of Behavioral and Social Sciences and Education. Board on Life Sciences, Division on Earth and Life Studies. Washington, DC: The National Academies Press.

[29] See for instance: Statistics Canada. 2010. "Projections of the Diversity of the Canadian Population, 2006-2031". Statistics Canada catalogue no. 91-551, and Statistics Canada. 2011. "Population Projections by Aboriginal Identity in Canada, 2006-2031". Statistics Canada catalogue no. 91-552.

- Length of projection horizons, including an understanding of short-term and long term;
- Communication of uncertainty;
- Assessing the efficacy of projection methods (for example when top down or bottom up approaches should be used) and assessing the performance of different projections;
- Developing a greater understanding of the users of projections.

68. The UNECE should maintain a publicly available online database of projections made by NSOs and International Organizations which includes the following basic information about the projections:

- Name of organization
- Base year of projection (including information about the accuracy of the base year – for example how far away it is from a Census).
- Date projection published
- Geography covered
- Consistency with or relation to any other projections (including any they supersede)
- Length of projection
- Level of detail produced (single age or age bands, every year or selected years, other variables)
- A basic description of the method used with links to published further details
- A brief description of how uncertainty is communicated
- A note of when projections are likely to be updated

69. The database should be searchable so that, for example, if a user wants to find the projections for a country or area they can identify all the projection runs that cover that geography.

70. The use of any such database should be monitored and ideally should include an element for stakeholders to give feedback on why they were looking for information on projections and what they want to use them for.

71. It is recommended that the international community stays abreast of further developments in microsimulation models for population projections. Such models should prove powerful to answer more complex demand for projections of variables beyond age and sex.

72. The UNECE could investigate the option of producing and disseminating a guide of best practices in population projections. This publication would stress best practices in the field of population projections regarding methodology, horizon, number of scenarios, dissemination and communication. Such a document would likely increase the comparability and quality of the population projections performed by UNECE member countries.

Annex A

A. Summary of current country population projections

Country	*Latest base point*	*Frequency of production*	*Methodology notes*	*National Horizon*	*Are probabilistic methods used and/or stochastic projections produced*	*How is uncertainty expressed for users?*	*Frequency of sub-national projections*	*Sub-national projections controlled to national projections?*
Australia	30 June 2012	Periodically, had been every 2-3 years but a 6 year gap between this set and previous set	Cohort component	To 2101 89 years	No	Three key variants produced	At state/territory level the same as national projections	Yes, but only run 2013 - to 2061
Belgium	1 Jan 2013	1 year	Cohort component	50 years	No			Yes
Canada	Mid-2013	About every five years, based on the census cycle.	Cohort-component method. Assumptions based on past trends and consultation process.	50 years for Canada, 25 years for provinces and territories.	No. Specific population projections for sub-groups of the population are available through micro-simulation.	Variant projections are produced using plausible alternative assumptions for fertility mortality and migration	Same as national.	Yes, as the "bottom-up approach" is used. Thus, Canada is computed by summing the individual provinces and territories.
Denmark	2014	1 year	Deterministic model	To 2050 (35 years)	No			

Country	*Latest base point*	*Frequency of production*	*Methodology notes*	*National Horizon*	*Are probabilistic methods used and/or stochastic projections produced*	*How is uncertainty expressed for users?*	*Frequency of sub-national projections*	*Sub-national projections controlled to national projections?*
Finland	2012	3 years	Cohort component method	To 2060 (48 years)	No			
France	1 Jan 2007	The current projections were published in 2010 Previous projections had run from 1 Jan 2005 and were published in 2006.	Cohort component, trend based assumptions	To 2060 (pub Oct 2010)	No	Through variant projections	Unclear	horizon to 2040 (pub Dec 2010)
Germany	31 Dec 2008	Previous had 2 year gap – however no projections carried out since 2009	Cohort component Use experts to advise on trends and analysis	To 2060 52 years	No	Variant projections are produced using plausible alternative assumptions for fertility mortality and migration	Projections to Länder level produced with national projections	Yes at Länder level
Italy	1 Jan 2011	Previous 4 years earlier	Cohort component	To 2065	No	2 Variants are produced for high and low populations, varying all three components.	Same as national	Projections are produced to the level of region at the same time as the national level
Netherlands	1 Jan 2013	Biennial for full set on even number base years with 'prognoses'	Cohort component with stochastic methods used	To 2060	Yes	For main projections probabilities are shown	Not clear	Not clear

Country	*Latest base point*	*Frequency of production*	*Methodology notes*	*National Horizon*	*Are probabilistic methods used and/or stochastic projections produced*	*How is uncertainty expressed for users?*	*Frequency of sub-national projections*	*Sub-national projections controlled to national projections?*
		produced on odd numbered years						
New Zealand	30 June 2011	Biennial - mainly	Cohort component stochastic model for 2011 based national set	To 2061 50 years	Yes	Fan charts	Every 5 years But update done. Latest are 2006 to 2031 Next due 2015 stochastic methods being researched for these.	Yes
Norway	1 Jan 2014	biennial	cohort component method is applied, using probabilities for all components including migration	To 2100 (86 years)	No	Variant projections are produced with variants of all components, including internal migration	Made at the same time as national projections, but latest set only projects to 2040.	Yes
Portugal	2012		Cohort component	50 years	No	4 Variants available		
Spain	1 Jan 2012	Every 3 years	Cohort-component	40 years to 2052	No	No numeric indication of uncertainty	1 year (10 year horizon)	Yes
Switzerland	1 Jan 2010	5 years	Cohort component	50 years	No	Many scenarios available	Every 5 years	Yes

Country	*Latest base point*	*Frequency of production*	*Methodology notes*	*National Horizon*	*Are probabilistic methods used and/or stochastic projections produced*	*How is uncertainty expressed for users?*	*Frequency of sub-national projections*	*Sub-national projections controlled to national projections?*
United Kingdom	Mid-2012	Normally every two years – interim sets may be produced around Census years	Cohort component method, expert extrapolation of trends in components	Focus on first 25 years – projections run for 100 years to 2112	No	Variant projections are produced using plausible alternative assumptions for fertility mortality and migration	For England same as national. Other countries of UK vary	Yes for England, Scotland and Northern Ireland.

Note: No national population projections were found for the following countries: Andorra, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Georgia, Greece, Hungary, Israel, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Republic of Moldova, San Marino, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

B. Key information about population projections

1. Australia

1. The Australian Bureau of Statistics latest projection of Australia's population by age and sex is for the period 30 June 2013 to 2101, and projections of the states, territories and capital cities/balances of state for the period 30 June 2013 to 2061. The base is 30 June 2012 and these figures are preliminary estimated resident population.

2. Three main series of projections are produced (Series A, B and C) as well as other series for analytical purposes.

3. Their website says "Assumptions have been formulated on the basis of demographic trends over the past decade and longer, both in Australia and overseas, in conjunction with consultation with experts at the national and state/territory level. They do not specifically attempt to allow for non-demographic factors (such as major government policy decisions, economic factors, catastrophes, wars, epidemics or significant health treatment improvements) which may affect future demographic behaviour or outcomes."

2. Canada

4. Statistics Canada produces population projections for Canada, provinces and territories about every five years, following the census and population estimates program cycles.

5. Statistics Canada's Policy on Estimates with Future Reference Dates states that 1) mathematical models used need to be open to public scrutiny, 2) assumptions must be clearly defined and presented, 3) more than one scenario must be made available and none should be qualified as "the most probable" 4) projections results must be reproducible.

6. Projections for Canada, provinces and territories are computed using the cohort-component method and are based on the latest population estimates available at the time of the production. Multiple assumptions regarding fertility, mortality, immigration and non-permanent residents, emigration, and interprovincial migration are developed on the basis of past trends, but also on the basis of a large consultation with key stakeholders and partners such as the provincial and territorial statistical focal points, the Advisory Committee on Demographic Statistics and Studies and several federal departments. These assumptions are used to build multiple variant scenarios in order to reflect the uncertainty inherent to all projection exercises.

7. Statistics Canada recently expanded its consultation process by surveying the Canadian community of demographers about their opinion of future demographic trends. The impetus for this venture and the survey design were inspired in large part by recent examples from agencies such as the ONS, INSEE and IIASA. The inputs from the survey were used to estimate plausible targets for the main components of the growth and a variance around these targets in a consistent manner from one component to the next

8. Over the last ten years, Statistics Canada has also developed population projections using microsimulation for specific sub-groups of the population (immigrants, visible minority groups, religious denomination, mother tongue, education, labour force) and at sub-provincial geographical levels. Microsimulation techniques facilitate the inclusion of several variables beyond age and sex and the consideration of differentials in demographic behaviours between sub-groups of the population (composition effects). These more detailed projections are based on the latest census microdata file, but also draw on a large number of other data sources to compute numerous input parameters, including censuses, administrative data, surveys and record linkages. These projections are complementary to

the national projections, addressing external requests and internal needs (such as survey weighting).

9. Key stakeholders of Statistics Canada's population projections include federal, provincial and municipal departments and agencies, the private sector, think tanks, academics and researchers.

3. France

10. The Institut National de la Statististique et des Études Économiques (INSEE) produce sets of projections. The frequency is unclear but a 1 January 2005 based set were produced in 2006 and a 1 January 2007 based set were produced in 2010.

11. The projections relate to Metropolitan France and the latest set run until 2060.

12. In terms of sub-national projections they are made by INSEE on the basis of the results of the population census. They are made for the whole of a territory or for any area composed of several municipalities with a total of over 50,000 inhabitants (a department, a region, an urban area, major towns or any ad hoc territory).

13. It is not clear whether these sub-national projections are made consistent with the national projections.

4. Germany

14. The Federal Statistical Office produces national population projections periodically, previously every two years, although the latest set with the base of 31 Dec 2008 were produced in 2009 with further detail published in 2010. The NSI is currently integrating the results of the 2011 Census so projections are likely to be made again once that task is complete. The horizon for the latest set of projections is to 2060.

15. At the same time as projections are produced at the national level the projections are also produced at the Länder level. This is still a fairly high level geography. Projections are not easily found below Länder level – if they are produced it is likely that they are the responsibility of the statistical offices in each area.[30]

16. The projection assumptions are produced using a combination of trend analysis and expert opinion and judgement.

17. Similar to the UK, Germany produces plausible alternative assumptions which are used to produce alternative projection runs to indicate uncertainty to users. These only appear to be done at the national level.

5. Italy

18. L'Istituto nazionale di statistica periodically produces national population projections. The latest set has a base point of 1 January 2011. The projections are described as having three phases. They are aimed at the future demographic development of the country in the short, medium and long term. They advise that the long-term data should be treated with extreme caution.

6. Netherlands

19. The Dutch Centraal Bureau voor de Statistieik have a bi-annual cycle of producing population projections. These are produced for even numbered base years. For odd

[30] See for example https://www.statistik.bayern.de/statistik/byrbz/

numbered years - a 'Core Prognosis' on the future population is released (for the same period as the projections). The core prognosis is based on the most recent data on fertility, mortality and migration with less analysis and only one projection is produced. The latest publication -28 Jan 2014 release- is only in Dutch and is the Core Prognosis for the period 2013-2060:

20. There is a difference between the 2012 based long term projections and the 2013 based Core Prognosis, which came out lower than the long term projections, mainly because of a higher level of emigration than was assumed in the projections.

7. New Zealand

21. Statistics New Zealand, for the first time, applied a stochastic (probabilistic) approach to producing population projections for the latest, mid-2011 based set. They provided the following commentary "Stochastic population projections provide a means of quantifying demographic uncertainty, although it is important to note that the estimates of uncertainty are themselves uncertain. By modelling uncertainty in the projection assumptions and deriving simulations, estimates of probability and uncertainty are available for each projection result. No simulation is more likely, or more unlikely, than any other. However, the simulations provide a probability distribution which can be summarised using percentiles, with the 50th percentile equal to the median. For each assumption, the median is equivalent to the 'medium' assumption used in previous deterministic projections. Similarly, the median stochastic projection is equivalent to the deterministic projection that combined the medium fertility, medium mortality, and medium migration assumptions in previous projections (ie series 5 in the 2009-base projections)."

22. At the same time an update was produced to the sub-national projections. This was not done on a stochastic basis but there are plans to produce the next set of sub-national projections using the probabilistic approach.

8. Norway

23. Statistics Norway produces new sets of projections every two years. The cohort component method is used. Probabilities are used for all components including migration. The projections are made at national and sub-national level and are run at the national level to 2100 and the sub-national projections until 2040.

24. Their website has a helpful paragraph on the use of the projections which says "The most important users of Statistics Norway's population projections are public and private planning bodies at the municipal, county and central government levels, as well as journalists, researchers, politicians and the general public. Every year, there are more than 35,000 downloads of the population projections from SSB's StatBank Norway. The projections are also used internally in SSB, for example as input in macroeconomic models such as KVARTS, MODAG and MSG, and in the micro-simulation model MOSART."

9. Spain

25. The Instituto Nacional De Estatistica (INE) normally produces long-term national projections every three years.

26. Projections relate to the normally resident population of Spain. This includes all long-term international migrants.

27. Short-term projections at a sub-national level are produced for 10 years forwards. These are produced every year.

28. The projections are based on a now cast of the population at the 1st of January, the latest base being 1 January 2012.

29. Projections appear to be predominantly trend based, based on fairly short runs of historical data.

30. It does not appear as though any indications of uncertainty are produced alongside the projections.

10. United Kingdom

31. The Office for National Statistics (ONS) in the UK normally produces national population projections every 2 years on behalf of the National Statistician and the Registrars General of Scotland and Northern Ireland.

32. Projections relate to the usually resident population of the UK and its constituent countries, regardless of their nationality. The usually resident population includes all long-term international migrants (people changing their country of usual residence for at least one year). However, it does not include short-term migrants who come to the UK for less than a year.

33. The projections are based on the population estimates at a given base date and a set of underlying demographic assumptions regarding future fertility, mortality and migration. The assumptions are based on the best statistical evidence available at the time agreed in liaison with the devolved administrations – Welsh Government, National Records of Scotland (NRS) and Northern Ireland Statistics and Research Agency (NISRA) - following consultation with key users of projections in each country and advice from an expert academic advisory panel.

34. The primary purpose of the national population projections is to provide an estimate of the future population of the UK and its constituent countries which is used as a common framework for national planning in a number of different fields. They are also used as the base for other official population projections such as sub-national projections, household projections and in the calculation of life tables.

35. Due to the inherent uncertainty of demographic behaviour, any set of projections will inevitably prove incorrect, to a greater or lesser extent, as a forecast of future demographic events or population structure. To give users of the projections an indication of this uncertainty, a number of variant population projections are produced based on alternative assumptions of future levels of fertility, mortality and migration.

36. Projections below national level are the responsibility of each country within the United Kingdom. Thus ONS produce projections for England only, National Records Scotland (NRS), Welsh Government (WG) and the Northern Ireland Statistics and Research Agency (NISRA) produce projections for their own country. It is notable that while ONS, NRS and NISRA constrain the sub-national projections to the national projections Wales do not.

11. United States of America

37. The US Census Bureau Population Projections Program produces projections of the United States resident population by age, sex, race, and Hispanic origin. The 2012 National Projections are based on the July 1, 2011 population estimates, which are based on the 2010 Census, and provide projections of the population for July 1, 2012 to July 1, 2060. The projections were produced using a cohort-component method and are based on assumptions about future births, deaths, and net international migration. The Census Bureau releases new national projections periodically.

38. The 2012 National Projections include a main series and three alternative series. These four projections series provide results for differing assumptions of net international migration. The main series, referred to as the Middle series, was released in December

2012. The alternative series, released in May 2013, were based on assumptions of low, high, and constant levels of net international migration. All other methodology and assumptions, including fertility and mortality, are the same as those used in the Middle series. The three alternative series are useful for analyzing potential outcomes of different levels of net international migration.

39. The website also notes in the "About the statistics" page that Eurostat also produce projections for Norway. The "about the statistics" page is an excellent example to other NSIs of how to communicate about statistics.[31]

C. Web links

Country	Web links
Australia	http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3222.0Main+Features12012%20(base)%20to%202101?OpenDocument
Canada	Population Projections for Canada, Provinces and Territories http://www.statcan.gc.ca/pub/91-520-x/91-520-x2010001-eng.htm Projections of the Diversity of the Canadian Population, 2006 to 2031 http://www.statcan.gc.ca/pub/91-551-x/91-551-x2010001-eng.htm Population Projections by Aboriginal Identity in Canada (91-552-X) http://www.statcan.gc.ca/pub/91-552-x/91-552-x2011001-eng.htm Projected trends to 2031 for the Canadian labour force http://wwwstaging.statcan.gc.ca/pub/11-010-x/2011008/part-partie3-eng.htm
France	http://www.insee.fr/fr/publications-et-services/default.asp?page=dossiers_web/projections-population/projections-population.htm
Germany	https://www.destatis.de/EN/FactsFigures/SocietyState/Population/PopulationProjection/PopulationProjection.html
Italy	http://demo.istat.it/uniprev2011/note.html
Netherlands	http://www.cbs.nl/NR/rdonlyres/5631920F-F0CA-4D33-8B0C-28CB79EC9AAB/0/20140102b15art.pdf (latest publication - in Dutch)
New Zealand	National http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationProjections_HOTP2011.aspx Sub-national http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationProjections_HOTP0631UpdateOct12.aspx
Norway	http://www.ssb.no/en/befolkning/statistikker/folkfram/aar/2014-06-17#content
Spain	Long-term national projections http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft20%2Fp251&file=inebase&L=1 Short-term sub-national projections http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft20%2Fp269&file=inebase&L=1

[31] http://www.ssb.no/en/befolkning/statistikker/folkfram/aar/2014-06-17?fane=om#content

United Kingdom	National http://www.ons.gov.uk/ons/rel/npp/national-population-projections/2012-based-projections/index.html Sub-national England http://www.ons.gov.uk/ons/rel/snpp/sub-national-population-projections/2012-based-projections/index.html Wales http://wales.gov.uk/statistics-and-research/local-authority-population-projections/?lang=en Scotland http://www.gro-scotland.gov.uk/statistics/theme/population/projections/sub-national/ Northern Ireland http://www.nisra.gov.uk/demography/default.asp47.htm
USA	http://www.census.gov/population/projections/data/national/2012.html